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as they are distributed in the layers and shells of the Lewis-Langmuir static atom. The ratio, ν/ν_{∞}, of the K critical absorption frequency for tungsten to the Rydberg fundamental frequency is 5118 according to the theory, which is exactly our experimental value (see table 1). The agreement to four figures between the two values must be regarded as a matter of chance, however, as the errors in both the experimental and calculated numbers amount to a fraction of 1%.

[1] See Sommerfeld's paper on the fine structure of the β-line (*Münchener Akademie,* June 1, 1918 (367)).

[2] Professor Siegbahn kindly communicated these results by letter.

[3] *Physik. Zs.,* **19,** 1918 (441, 465).

[4] *Phil. Mag.,* June, 1919 (601).

[5] *Comptes Rendus,* May 25, 1920 (1245).

[6] *Sitz. Ber. Bayr. Akad. Wiss.,* June, 1918.

[7] Since this explanation was presented to the Physical Society in February, papers by W. Kossel and A. Sommerfeld (*Zeitschrift für Physik,* Jan., 1920) have reached us. In these papers the same explanation for the discrepancy is discussed as that here put forward.

STUDIES OF MAGNITUDE IN STAR CLUSTERS, XII. SUMMARY OF A PHOTOMETRIC INVESTIGATION OF THE GLOBULAR SYSTEM MESSIER 3[1]

BY HARLOW SHAPLEY AND HELEN N. DAVIS

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Communicated by G. E. Hale, June 24, 1920

1. The study at Mount Wilson of the distances and structure of stellar clusters is of necessity based upon observations extensive in number and considerably varied in character. When general and comprehensive results have been obtained for a few typical systems, it becomes possible to interpret more accurately the less detailed observations on other clusters, and to place greater confidence in the hypothesis of the galactic system that has developed from the investigations of cluster and variable stars.

For two open clusters, Messier 67 and 11, and for two globular clusters, Messier 13 and 3, fairly complete surveys of the photographic and photovisual magnitudes of the individual stars have now been carried through and published in some detail; for about forty other systems the photometric and spectral investigations have been of a special character, and, in publishing the results, the observational data have for the most part only been summarized.

2. The catalogue of magnitudes and colors of 848 stars in Messier 3, which is appearing as *Mount Wilson Contribution* No. 176,[2] was begun in 1915. Fourteen photographs, made at the primary focus of the 60-inch telescope, have been used for the ten thousand measures of magnitude involved in the investigation. Special care was taken to look into the

accidental and systematic errors; the average probable error of a magnitude is about 0.04. Since the distance of Messier 3 appears to be known with higher accuracy than that of any other stellar cluster, we have in this photometric catalogue a useful collection of data on the *absolute* brightness of stars—data that will become still more valuable as spectral observations are extended.

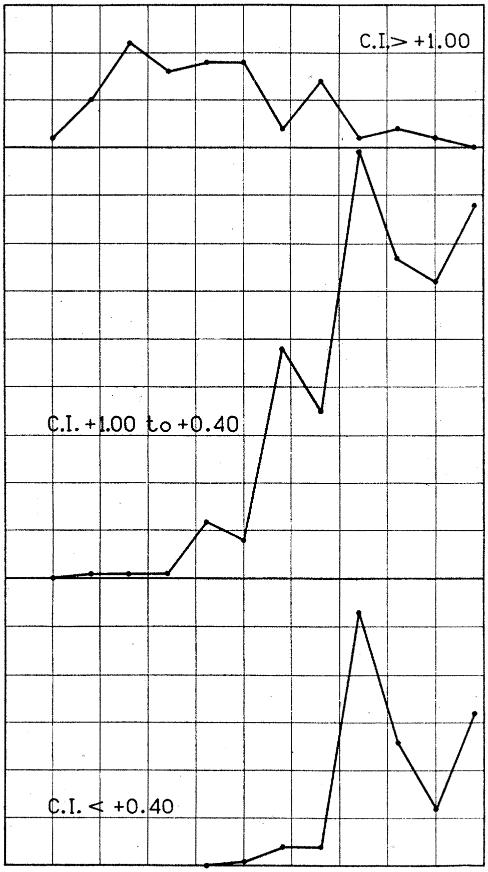

FIG. 1

Frequency of absolute photovisual magnitudes (abscissae) in Messier 3. Upper, middle, and lower curves are for red, yellow, and blue stars, respectively. Ordinates are numbers of stars for intervals of 0.4 in absolute magnitude.

3. Von Zeipel's catalogue of positions[3] is used as the basis of the system of coördinates and of the system of numbering. For 340 stars fainter than the limit of his catalogue approximate positions have been determined from Mount Wilson plates.

The magnitudes of stars within 1'.8 of the center have not been measured. Outside this crowded central region the catalogue includes practically all cluster stars to the apparent photovisual magnitude 16.8, and it is nearly complete to the seventeenth magnitude. Excluding questionable values, and also results for 64 stars fainter than pv. mag. 17, we have 750 magnitudes available for statistical discussion.

4. By accepting the parallax of the cluster as 0″.000072 (*Mount Wilson Contribution* No. 152), zero absolute magnitude is found to correspond to apparent magnitude 15.72. The frequency of stars may be determined throughout the interval of absolute photovisual magnitude from the brightest star in the cluster, -3.5, to a little fainter than $+1.0$. All the stars studied, therefore, are giants, the faintest ones catalogued being some twenty times as bright as the sun.

5. The frequency curves of absolute magnitude, which are graphs of the so-called luminosity law, are shown in the accompanying figure for red, yellow, and blue stars, separately. The curves are comparable with the combined results for three clusters in figure 4 of the preceding communication of the series,[4] except that in the present case a fainter magnitude is reached.

The preliminary maximum in the curve for blue stars (and less distinctly for yellow stars) at absolute magnitude -0.3 shows the highly significant excess of stars at the median magnitude for cluster-type variables.[5] The variety and lack of symmetry in these luminosity curves, and the certain existence of preliminary maxima, suggest the impracticability of using a small fragment of the general luminosity curve (all colors combined) as a means of estimating the distances of globular clusters—a procedure recently followed by Schouten and by Coeberg with surprizing results.

6. No conspicuous dependence of mean brightness or color on distance from the centre is found in Messier 3. The characteristic relation of mean color to absolute brightness appears, much as in figure 3 of the communication referred to above; and the maximum frequency of color index falls between $+0.4$ and $+0.8$, quite in agreement with the earlier results for Messier 13.

7. A separate investigation of the color curves and the constancy of period is under way for the numerous Cepheid variables in Messier 3. It will include an examination of the small light variations that appear in a number of stars very similar in color and absolute brightness to the typical cluster-type Cepheid, but not heretofore recognized as variable.

8. The apparent visual magnitude of the cluster as a whole is 6.6. The integrated absolute magnitude is, therefore, $6.6 - 15.7 = -9.1$, which is equivalent to 360,000 times the light emission of the sun, or to a total energy of radiation of 1.4×10^{39} ergs a second.

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[1] Messier 3 = G. C. 3636 = N. G. C. 5272; R. A. = $13^h\ 37^m\ 35^s$, Decl. = +28° 52′ 56″, 1900; galactic longitude = 8°, galactic latitude = +77°.

[2] Shapley, Harlow and Davis, Helen N., *Astrophys. J., Chicago, Ill.*, **51**, 1920 (140–178).

[3] Von Zeipel, H., *Annales de l'Observatoire de Paris, Memoires*, **25**, 1908 (F1–F101).

[4] Shapley, Harlow, These PROCEEDINGS, **6**, 1920 (293–300).

[5] *Ibid., Mt. Wilson Contribution* No. 155, 1917 (1–12); No. 175, 1919 (1–13), p. 10.

THE INFLUENCE OF ENVIRONMENT UPON DEVELOPMENT

BY FRANZ BOAS

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Read before the Academy, April 27, 1920

During the last ten years I have carried on a number of investigations on the relative influences of heredity and environment upon human types. On the whole the results show that each hereditary type can be considered as stable only in a stable environment, and that with a change of environment, many of the characteristic features of the body undergo changes. These results have been corroborated later on by investigations on immigrants in Boston and in certain respects also by Dr. Hrdlička's observations on Americans whose ancestors have been residents of this continent for several generations.

Ever since Gould and Baxter's investigations on the soldiers enlisted during the war of the Rebellion and since Bowditch's investigations of Boston school children, it has been known that the bulk of the body differs not only according to descent, but also according to social position of the child. The children of the poor are not so tall as the children of the well-to-do. We have, however, never been able to establish definitely whether children who are small for their ages will also be small as adults, or whether a compensatory growth occurs during the period of adolescence. I have shown in previous investigations that children who are retarded will at a later time have a much more rapid growth than children who in the early years of their lives are accelerated. This observation has been confirmed by a study of material which I placed at the disposal of Dr. Wissler. At that time, however, we were not in a position to extend these observations up to the adult stage.

Through the courtesy of Mr. Wilson Farrand, Headmaster of the Newark Academy, I have been able to collect observations on about 120 individuals whose measurements extend from the 11th year to adult life. The study of this series shows conclusively that from 11 years on, a short child will also be on the average short as an adult, while a tall child will be tall as an adult. The absolute amount of increment for a short child, from the age of 11 years up is, however, considerably larger than the total increment for a tall child of the same age, so that the previous observation may be extended for the whole period of growth. It seems likely that the relation between initial stature and increment will be